AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Design and Production Engineering

Formability and Rolling of Ductile Iron Subjected to Different Thermo-Mechanical Treatments

A Thesis submitted in partial fulfillment of the requirements of the degree of

Master of Science in Mechanical Engineering

(Design and Production Engineering)

By

Marwan Faisal Zaki Abdelwahed

Bachelor of Science in Mechanical Engineering
(Design and Production Engineering)
Faculty of Engineering, Ain Shams University, 2014

Supervised By

Prof. Dr. Mohamed Ahmed Taha

Dr. Eman El - Shenawy

Cairo - (2017)

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Statement

This thesis is submitted as a partial fulfillment of Master of Science in Mechanical Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

Signature

……...…….

Marwan Faisal Zaki

Date:

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Abstract

Ductile cast iron (DI) is an iron-carbon alloy, in which the structure is composed of graphite nodules embedded in a steel matrix. The thermo-mechanical behavior of ductile cast iron was studied by using the thermomechanical simulator Gleeble-3500 and Dilatometer Dil 805D. This was to predict the rolling condition for producing sheets and strips. The physical simulation of hot rolling process was conducted on specimens at a range of deformation temperatures 950 to 800 °C at three different strain rates; namely 0.05, 0.1 and 0.5 s^{-1}. The results obtained from the tests at the applied strain rates, showed minimum values of compressive stresses at 850 °C. By increasing the deformation temperature up to 900 °C, the compressive stresses increased to reach the maximum values, beyond which the compressive stresses decreased again. Furthermore, remarkable dynamic recrystallization was observed at deformation temperatures of 800 and 850 °C with applied strain rates of 0.05 and 0.1 s^{-1}. Moreover, three deformation hits were successively applied on a test-specimen at temperatures namely; 900, 850 and 750 °C with the same strain rate of 0.1 s^{-1}. No cracks were observed, up to 50% deformation, after the three-consecutive hits. Gleeble test results were correlated with the microstructure observations on the quenched specimens at their deformation temperatures; where the changes in structure and graphite morphology were reported. The results were analyzed so that to determine the suitable rolling conditions required for safe rolling of the ductile iron plates. As a conclusion, ductile iron could be safely rolled at different deformation temperatures and strain rates studied in this work. The rolled sheets and strips exhibit Ferritic - Martensitic structure in which graphite nodules were somewhere elongated.

Keywords:

Ductile Cast Iron, Thermo-mechanical behavior, Gleeble-3500, Hot Rolling, Physical simulation

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List of Abbreviations

ASU	: Ain Shams University
CCT	: Continuous Cooling Transformation
CE	: Carbon Equivalent
CI	: Cast Iron
CMRDI	: Central Metallurgical Research Institute
CR	: Cooling Rate
DI	: Ductile cast iron
DRX	: Dynamic Recrystallization
EDX	: Energy Dispersive X-ray Spectroscopy
ESEM	: Environmental Scanning Electron Microscope
GCI	: Grey Cast Iron
Gr	: Graphite
IMET	: Institute of Metallurgy
LVDT	: Linear Variable Differential Transformer
SH	: Strain Hardening
Temp.	: Temperature
TMB	: Thermomechanical Behavior
TTT	: Time Temperature Transformation
TUC	: Clausthal University of Technology
UTS	: Ultimate Tensile Strength